hence does not contribute to ATP synthesis, the function of the pathway has been clarified in recent years. It is expressed and activated during periods of stress, for example in response to wounding or flowering.[1] This activation provides plant mitochondria with a mechanism by which an increased rate of respiration can be achieved. There is no evidence that Ggt responds to stress in a similar way, so its alternative pathway must have a different function.

One explanation for the presence of the alternative oxidase in Ggt is that its K_m for oxygen is lower than that of cytochrome oxidase for oxygen. This would suggest that the constitutive expression of the alternative oxidase could be an adaptive response to low oxygen concentrations often associated with the environment surrounding plant root systems.

Overall this study has demonstrated that variation in the components of the electron-transfer chain within the mitochondria of filamentous fungi is possible (Fig 1B). It also implicates involvement of novel complexes in the process of electron transfer, and ultimately in providing cellular ATP. With the development and launch of novel chemistries targeting energy production, such as the methoxyacrylates, the requirement to characterise fully fungal respiratory chains is essential in order to adopt suitable resistant management strategies and for the design of novel chemistries.

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Synthesis and herbicidal activity of pyrimidine derivatives

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Abstract: A new class of 2-benzoylpyrimidines exhibited good pre- and post-emergence herbicidal activity at low rates. The selectivity and herbicidal activity were largely affected by the substituents on the phenyl and pyrimidine moieties. The compound having a trifluoromethyl group at the 4-position of the pyrimidine showed good selectivity toward soybean in pre-emergence treatment, while the compound having an isopropyl group showed excellent herbicidal activity against barnyardgrass in paddy field in post-emergence treatment. The structure–activity relationship and mode of action of this family of compounds are discussed.

Keywords: benzoylpyrimidine; herbicidal activity; selectivity; cell division inhibition

A number of pyrimidine derivatives are known to be bioactive, the pyrimidine substructures often being found in well-known pesticides such as herbicidal sulfonylureas and pyrimidinylsalicylic acids, and in fungicidal anilinopyrimidines. The two types of pyrimidine herbicide eg sulfometuron-methyl and pyriminobac-methyl, both inhibit acetolactate synthase (ALS) in spite of the structural differences in the bridge between the pyrimidine and benzene rings, ie 'sulfonylurea' in sulfometuron-methyl and 'ether' in pyriminobac-methyl. The sulfide analogues of the ether compounds such as pyrithiobac-sodium are also known as potent ALS-inhibiting herbicides. On the other hand, the anilinopyrimidines, such as mepanipyrim, having an amino bridge between the 2-position of pyrimidine and a phenyl group, show fungicidal activity. We were interested in the role of the bridge moiety in biological activity, and a survey of the literature and patents of the related compounds revealed that there had been few reports on the synthesis of 2-benzoylpyrimidines (**1**; Table 1) having a carbonyl group at the bridge moiety.[1–3] We have accordingly investigated the synthesis of compounds of type **1** as new candidate pesticides, since their biological properties were unknown.

The 2-benzoylpyrimidines (**1**) were synthesized by the oxidation of the corresponding benzylpyrimidines, which were obtained from the appropriate benzylamidines and β-ketoesters or β-diketones (Fig. 1). Among a series of the benzoylpyrimidines, the compounds having a trifluoromethyl or an isopropyl group at the 4-position (R_1) of the pyrimidine ring exhibited potent activity against weed species and selectivity toward soybean in pre-emergence treatment. Investigation of the effects of the benzene-ring substituents revealed that the 2- or 2, 6-substituted compounds, such as 2-chloro, showed a potent activity. On the other hand, the 2, 3- or 2, 4-disubstituted compounds were less active, and the

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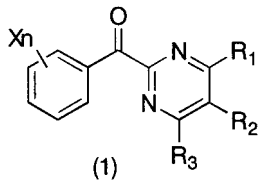
Table 1. Pre-emergence herbicidal activity against *Setaria faberi*

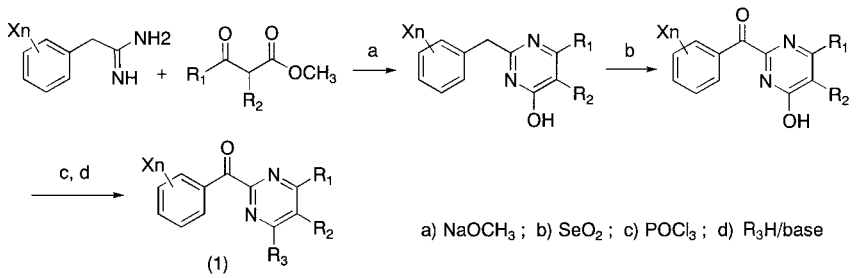


(1)

Compound	Xn	R_1	R_2	R_3	Herbicidal activity ED_{90}(g ha^{-1})
1	2-Cl	CH_3	H	OCH_3	4000
2	2-Cl	CF_3	H	OCH_3	1000
3	2-Cl	$CH(CH_3)_2$	H	OCH_3	1000
4	2-Cl	CF_3	H	SCH_3	1000
5	2-Cl	CF_3	H	$NHCH_3$	2000
6	2-Cl	CF_3	CH_3	OCH_3	1000
7	H	CF_3	H	OCH_3	4000
8	2-CH_3	CF_3	H	OCH_3	2000
9	3-Cl	CF_3	H	OCH_3	>8000
10	4-Cl	CF_3	H	OCH_3	>8000
11	2,3-di Cl	CF_3	H	OCH_3	4000
12	2,4-di Cl	CF_3	H	OCH_3	4000
13	2,6-di Cl	CF_3	H	OCH_3	500
14	2,6-di Cl	$CH(CH_3)_2$	H	SCH_3	1000
15	2,6-di Cl	CF_3	—CH_2CH_2S—		63
16	2,6-di Cl	CF_3	—CH=CHS—		31
17	2,6-di Cl	$CH(CH_3)_2$	—CH=CHS—		500
18	2,6-di Cl	CF_3	—CH_2CH_2O—		63
19	2,4,6-tri Cl	CF_3	—CH_2CH_2O—		2000
20	2-F,6-Cl	CF_3	—$CH_2CH_2CH_2O$—		63
21	2-F,6-Cl	CF_3	—CH=CHO—		31
22	2-F,6-Cl	CF_3	—CH=CHS—		16

3- or 4-substituted analogues were not active at all. Methyl, trifluoromethyl and other halogens than chlorine at the 2-position decreased the activity. Quantitative analysis of the structure–activity relationship (QSAR) suggested that there existed optimum values in hydrophobicity and bulkiness of the benzene-ring substituents, whereas the electronic properties of the substituents were not significant in accounting for activity. QSAR analysis for the pyrimidine moiety indicated that the compounds with electron-withdrawing groups were favorable for activity, and that hydrophobicity and volume of the substituents also affected the activity. The trifluromethyl group was then selected as one of the best substituents at the 4-position because of its hydrophobic and electronic properties.

Using the results of QSAR analysis, we have designed novel compounds having a fused ring structure at the 5- and 6-positions of the pyrimidine ring, which might satisfy the structural requirement for activity (Fig. 2). The fused pyrimidines with 5- or 6-membered heterocyclic systems gave very good activity against *Setaria faberi* Herrm at low rates in comparison with 6-methoxy- and 6-methylthio-substituted pyrimidines. The thieno- or furo-fused compounds especially showed excellent activity (Table 1). The substituents at the 2,6-positions on the benzene ring were important to increase herbicidal activity, and the best activity was obtained with compounds with 2,6-di-Cl or 2-F, 6-Cl; 2,4,6-tri-substituted analogs had markedly reduced activity. The substituent at the R_1-position of the fused pyrimidines was also important in controlling the selectivity between crops and weeds. Introduction of a trifluoromethyl group to this position resulted in good selectivity between soybean and weed species, whereas the corresponding compounds having an isopropyl group showed excellent selectivity between



a) $NaOCH_3$; b) SeO_2 ; c) $POCl_3$; d) R_3H/base

Figure 1. Synthetic route to 2-benzoylpyrimidines.

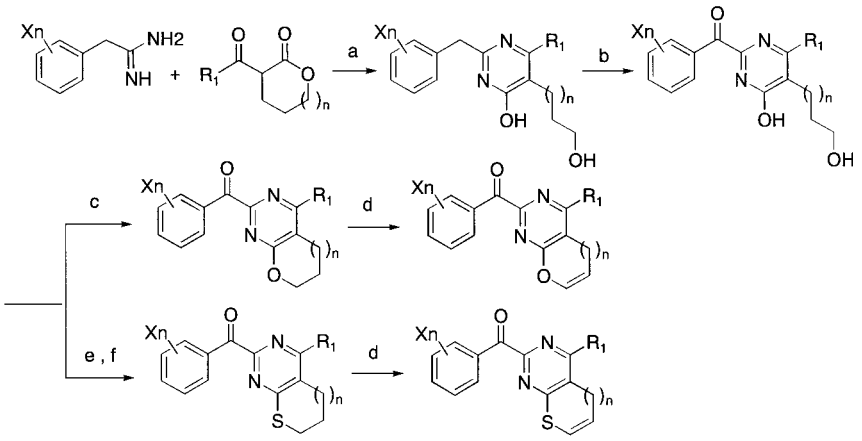


Figure 2. Synthetic methods for 2-benzoylpyrimidines with a 4,5-fused heterocyclic system.

transplanted rice and barnyardgrass. Compounds **22** and **17** were considered to be the best analogs with respect to excellent pre-emergence efficacy against troublesome weeds like giant foxtail, crabgrass and common lambsquarter in soybean fields as well as having good selectivity. These compounds could control barnyardgrass at low rates in pre- and early post emergence stage in paddy fields and showed long-lasting activity.

Elongation and cell division of treated plants were strongly inhibited by the benzoylpyrimidines and bulbous-shaped roots were also observed. Such phototoxic symptoms suggested that the mode of action was the same as with herbicidal dinitroanilines.[4]

The 2-benzoylpyrimidines shown above are a new class of herbicide with excellent activity against annual grass weeds and some broadleaved weeds in soybean and paddy fields.

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The mystery of the trichothecene 3-*O*-acetyltransferase gene: *Tri101* evolved independently of other trichothecene biosynthetic genes in the gene cluster

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Abstract: Trichothecene resistance is achieved *via* 3-*O*-acetylation on the biosynthetic pathway of deoxynivalenol in *Fusarium graminearum*. The responsible 3-*O*-acetyltransferase gene, *Tri101*, was located between the UTP-ammonia ligase gene and the phosphate permease gene, and not in the trichothecene biosynthetic gene cluster. As predicted by the presence of its homologues in yeasts, the resistance gene proved to have evolved independently of other biosynthetic genes.

In *Fusarium sporotrichioides*, *FsTri*101 (a functional homologue of *Tri101*) was also located these two 'house-keeping' genes. However, *FsTri101* appeared not to play a pivotal role for self-resistance, suggesting that other defensive options are the primary working strategies for the type A trichothecene producer.

Keywords: antibiotic resistance; *Fusarium* mycotoxin; gene cluster; independent evolution; trichothecene biosynthesis

Trichothecene mycotoxins are potent translation inhibitors of protein synthesis in eukaryotes and prevent polypeptide chain initiation/elongation by binding to 60S ribosomal subunits. We have shown that 3-*O*-acetylation of the ring works as a self-resistance mechanism for the t-type trichothecene producer *Fusarium graminearum* Schwabe F15. Based on this finding, the cDNA and cosmid clones for the related acetyltransferase gene, *Tri101*, have been isolated and characterized.[1] The *Tri101*-containing cosmid clones did not contain *Tri4*, *Tri5*, and *Tri6*, other trichothecene biosynthetic and regulatory genes isolated so far.[2]

Here we have sequenced the cosmids containing *Tri101* and found that this resistance gene is not

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